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UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

REPORT OF

AERIAL PHOTOGRAPHY AS A METHOD OF MAPPING YELLOW PINE AREAS TO SHOW LOSSES CAUSED BY BARKBEETLES.

Results of Tests Carried Out on the Sierra National Forest May, 1925, by the 15th Photo Section, Air. Service, in cooperation with the Bureau of Entomology, U.S. Department of Agriculture.

By
J.M.Miller,
Entomologist
U.S. Dept. of Agriculture

P.O. Box 3010,
Stanford University, Cal.
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GOVERNMENT PRINTING OFFICE

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I. Suggested Use of Airplanes for Forest Insect Surveys.

For some years forest entomologists have been considering the possibility of using the airplane to secure observations of areas infested by tree killing barkbeetles. The use of this method is suggested by the fact that trees infested or recently killed by barkbeetles are visible for a considerable distance, due to the yellow to red color of the foliage which contrasts with the normal green of the unaffected trees.

The application of data to be secured by aerial observations would be in the study of sample areas and also in the control surveys with the object of determining the general extent of the infestation and the location of infested trees that are to be cut and treated in controlling barkbeetle epidemics.

The air plane can be used by the forest entomologist for the purpose of general observation in the same way he uses high points of the topography to form his impressions and estimates of the amount of infestation in an area. By the use of a good base map, the general location and number of infested or recently killed trees can be estimated. The air plane undoubtedly has a field in this sort of work but this method has not as yet been given a satisfactory test.

Another method of securing the essential data is to photograph the area from the air so that the color of the insect killed trees will register by means of special filters. The proper Wratten color filters, when used on panchromatic plates and films can be made to emphasize the yellow and red colors of the affected trees. By this method the location of each tree can be shown in relation to the surrounding timber and other ground features.

II. Cooperation in Test of Aerial Photography.

In the spring of 1925 the necessary cooperation was arranged between the Air Service and the Bureau of Entomology to try out the Photographic method. This project was taken up by the field station of the Bureau of Entomology at Stanford University, Calif., with the 15th Photo Section, Air Service at Crissey Field, Presidio. The Bureau of Entomology made an allotment of $150.00 to reimburse the Air Service for expenses incurred on the project but owing to fiscal difficulties in transferring funds from one Department to another the Air Service paid the entire expense from its own funds. The Bureau of Entomology purchased one roll of special film to replace part of the material that was used.

Plans for the project were taken up with Lt. W.R. Taylor of the 15th Photo Section. It is largely through Lieutenant Taylor's efforts to work out the technique and his careful planning of the details of the project that this test was made possible.

III. Location of Areas.

The areas selected for the test were located near Northfork, Cal., on the Sierra National Forest. By using these areas it was possible to base at Crissey Field and the additional advantage was also afforded of using an area which was being surveyed by ground methods in a study of insect damage carried on by the Bureau of Entomology. Two areas were selected for photographing; one of approximately 3 sections at Cascadel, and another of 8 sections just north of Bass Lake.

IV. Preliminary Tests of Films and Filters.

The Air Service uses in its aerial photography the Eastman hypersensitized panchromatic film in rolls of about 110 exposures, 18 x 24 cm. The speed of the film is about twice that of the average orthochromatic film used in general photography.

Before attempting photographs from the air it was desireable to determine which of the Wratten filters were best adapted for use with this film in emphasizing the colors of insect killed trees. To determine this point Lt. Taylor made a trip to Northfork, May 4 to 6, and tested out the Wratten filters by using the aerial film in a graphlex camera. The various color phases of the insect killed trees were photographed from the ground at distances corresponding to those which would be used in aerial photography. It was found that the G filter gave sufficient contrast in the case of trees with yellow and sorrel foliage but in the case of trees which had developed to the dark red color stage the contrast was very light. The A filter gave strong contrasts with the red trees but because of the long exposures required it could not be used with the aerial camera. It was decided therefore to use the G filter, both because it permitted of exposures of 1/50 of a second or less and because the general balance of contrasts for the colors desired was much better than that secured with the A filter.

V. Scale of Aerial Map.

Two points were considered in determining the height at which the picutres were to be taken. One of these was to include a large enough area with each exposure so that for general mapping work the cost would be within reason. Another was to take the exposures at a height from the ground which would show all of the necessary detail but would reduce so far as practicable the disporportionate scale between the higher and lower elevations of mountainous topography.

Lt. Taylor decided to take these pictures with a 12 inch lens at a height of 9,000 feet above the average ground contour. As this contour varied from 3,000 to 4,000 feet it was necessary to fly at a height of 12,000 to 13,000 feet to make the exposures. This gave a map scale for the finished pictures of 750 feet to the inch, with each exposure covering approximately one square mile. With this scale it is possible to distinguish each individual mature tree on the ground, but it is doubtful if the necessary detail could have been seen if a smaller scale had been used.

VI. Date of Test and Completion of Aerial Map.

The actual flight was held up pending favorable weather conditions until May 26. The photographic plane and one observation plane left Crissey field at 10:00 a.m. and the areas at Northfork were reached at 11:30 a.m. About one hour was spent in running the strips. Both the Bass Lake and Cascadel areas were covered together with a considerable strip of the intervening territory. Altogether about 60 exposures were made.

A landing was made at 1:30 at Modesto, Calif., for gas and oil. The planes returned to the base field at Presidio at 4:30 p.M.

On the following day the finished prints from these exposures were matched at the laboratory at Crissey field so that a mosaic map of the areas covered was then available. Altogether about 20 sections were included in this map which gave an accurate base showing roads, trails, streams, type conditions, and other ground features. To have covered the same area so as to secure a base map by the ordinary timber reconnaissance methods would have required a field party of three men approximately 40 days.

VII. Interpretation of Results.

During June 1925 a series of ground surveys were carried out on the same areas and the finished prints of the aerial map were taken into the field and closely checked with ground conditions. It was found that all roads, trails, down logs or any object making a line on the ground registered in faithful detail. However, the primary object of this test was to determine whether the location of the insect killed trees could be brought out by the photographic method.

From this angle the prints were at first rather disappointing. They included an immense amount of fine and varied detail all of which must be interpreted from the standpoint of a photograph taken with Wratten G filters 9,000 feet directly above the subject. In the case of verticle objects such as trees it is only the crown that is seen.

The general form of the tree can be judged only by the shadow which it throws on the ground. As these exposures were made at high noon on May 26 the shadows were relatively short. The trees with yellow or red foliage appear as white spots in the finished picture and are not easily distinguished from any other objects of a similar color, except by the form of the shadow. The normal green trees, however, appear as dark spots so that it is possible to distinguish between the green and insect-killed trees. A great deal depends, however, upon the color of the back ground which consists of the ground cover under the insect-killed tree. If this happens to be the dark green bearclover the red tree stands out as a distinct white spot. However, if the tree is standing in a ground cover of dead pine needles there is no contrast between the crown of the tree and the background so that only the shadow indicates its location.

VIII. Results on Sample Plots.

On June 15 and 18 checks were made on two small areas by taking the prints into the field and comparing each individual tree with its image in the photograph. While this was slow and tedious work the identification of each individual tree was fairly easy because its location could be quite definitely fixed by the surrounding ground features such as trails, streams, open patches, down logs, etc., which could be readily identified in the photograph.

The following are the results from the yellow pine checked on these sample plots:

Plot	Color of Foliage	No trees Registered.		No. trees failed to register.	
Cascade1 (30 acres)	Fading	-		-	
	Sorrel and light red	1		-	
	Red	16		1	
		Total	17		1
Bass Lake (50 acres)	Fading	-		-	
	Sorrel and light red	28		-	
	Red	-		3	
		Total	28		3
	Total both plots		45		4

On these plots a little better than 90 percent of the insect-killed trees still retaining the discolored foliage registered so that they could be distinguished in the photograph. The failures were on trees which had advanced to the dark red color phase.

On the other hand it is sometimes very difficult to draw the line between green and insect-killed trees as they appear in the photograph. On these plots several trees were taken for bug trees in the photograph which were found to be normal green trees in the field. The

following notes were made on this phase of the check.

1. Yellow pine with heavy crops of new cones refract the light so that they appear as white tops in the photographs.

2. Trees on which a certain percent of the needles are red due to sickly tops, needlekilling fungi, etc., often register as white tops resembling the insect killed trees.

In most of the above cases, however, the tree with only partial red foliage does not show the positive white color as do the tops of trees with the entire foliage sorrel or red. It would probably be possible to distinguish these cases with practice. On the Bass Lake plot one green sugar pine registers as a white top tree but no explanation could be found for this except that the foliage was somewhatlighter in color than the surrounding yellow pine.

IX. Possible Applications of the Photographic Method.

1. Base Maps for Control Projects.

By this method accurate base maps showing type conditions as well as the main topographic features, drainage, etc., can be secured in such a short time that its use seems to offer some very apparent advantages in the planning of control projects where no base maps are available. Cost data furnished by the Air Service show that the cost of materials including films, developing, printing and personal expenses for making a mosaic map on a scale of 833 feet to the inch is around 68 cents per square mile. On a scale of 625 feet to the inch the cost is around $1.24 per square mile. In addition to this there must be figured the cost of operating the plane which includes gas, oil, pay of pilot, pay of photographer, travel expenses etc. This is estimated at $45.00 per hour. However, a photographic plane can map from 50 to 100 square miles in an hour so that this cost is not excessive. All items considered the cost of mapping a large forest area on a scale of 8 inches to the mile can probably be kept under $5.00 per square mile. By the ordinary methods of ground surveys the cost of making a base map will be at least $20.00 per square mile.

2. As a substitute for Marking and Mapping of Infested Trees.

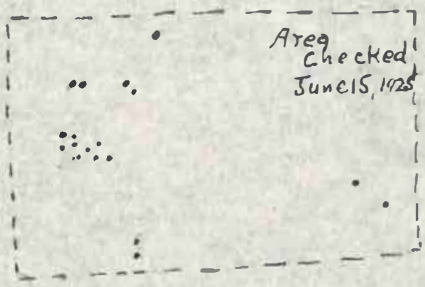
This work known as "spotting" is an essential phase of a control project. The infested trees must be distinguished from the recently abandoned ones and must be marked and mapped so that the control crews can be directed to them

It is evident that the photographic method cannot be used to supplant this necessary ground work. The infested trees cannot be distinguished from the recently abandoned ones in the photographs. This can only be done by making an actual examination of the tree itself. In some cases the infested trees do not show any discolored foliage so that external indications on the trunk, such as pitch tubes are the only evidence to guide the cruiser to the infested tree.

3. For Investigative Purposes as a Record of Conditions in Infested Areas.

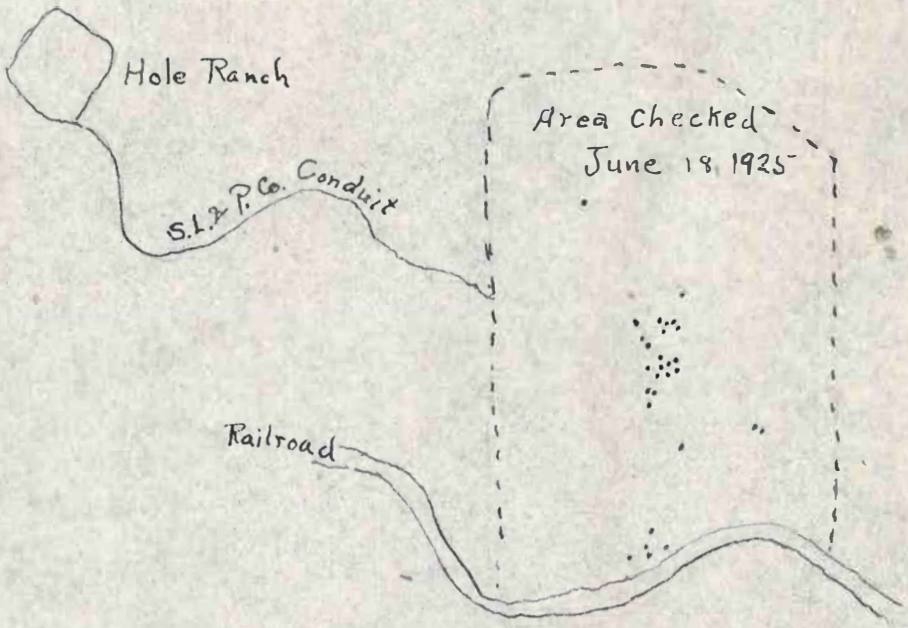
The detailed records which these photographs furnish is of unquestioned value for research purposes. They can be used to show the effects of infestations upon the forest type and cover, or the result of the effects of both fires and insects upon the forest cover.

The possibilities of this method have not been thoroughly determined by this one test and further experimentation seems desireable to thoroughly try it out from all angles.



Cascadel
Orchard

SECTION FROM CASCADEL UNIT SHOWING CHECK AREA



SECTION FROM BASS LAKE UNIT SHOWING CHECK AREA